

Deposition of Fixer and Overcoat by an Inkjet Printing System

BACKGROUND

[0001] A color inkjet printer includes different printheads for printing inks of different colors. The different colors are typically cyan, magenta, yellow and black.

[0002] During printing, the printheads deposit droplets of ink on a print medium. If the ink becomes smudged, print quality can be degraded.

SUMMARY

[0003] According to one aspect of the present invention, a printing system includes a fixer printhead, an overcoat printhead and at least one ink printhead. At least one ink printhead deposits drops of a colored ink on a print medium. The fixer printhead deposits drops of a fixer onto the deposited drops of the colored ink. The overcoat printhead deposits drops of an overcoat onto the deposited drops of the colored ink. Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Figure 1 is a schematic illustration of a printing system according to an embodiment of the present invention.

[0005] Figure 2 is an illustration of an embodiment of a printhead usable with the printing system of Figure 1.

[0006] Figure 3 is an illustration of a first embodiment of a method of operating the printing system of Figure 1.

[0007] Figure 4 is an illustration of a second embodiment of a method of operating the printing system of Figure 1.

[0008] Figures 5a-5d are illustrations of different printhead arrangements according to embodiments of the present invention.

[0009] Figure 5e is an illustration of a method of using the arrangement of Figure 5c to print a line.

[0010] Figure 6 is an illustration of a printing system according to another embodiment of the present invention.

DETAILED DESCRIPTION

[0011] As shown in the drawings and for purposes of illustration, an inkjet printing system includes printheads for applying ink, fixer and overcoat to print media. The fixer and overcoat react to produce a protective coating that increases permanence of the ink on the print medium (e.g., to reduce ink and highlighter smudge, to improve water fastness).

Examples of such fixer and overcoat are disclosed in assignee's U.S. Serial Nos. 09/556,033, "Polymer Systems For High Quality Inkjet Printing" by Gore filed Apr-20-2000, and 09/556,028, "Generation Of A Film On Paper For The Promotion Of Waterfastness And Smearfastness" by Schut filed Apr-20-2000, all of which are incorporated herein by reference

[0012] Reference is made to Figure 1. A printing system 110 includes a print head carriage assembly 112. The carriage assembly 112 includes a number of printheads 12a-12f. For the purpose of illustration, these printheads 12a-12f are further identified by the letters "F", "K", "C", "M", "Y" and "OC", respectively. The F-printhead 12a delivers a fixer; the K-printhead 12b delivers black ink; the C-printhead 12c delivers cyan ink; the M-printhead 12d, delivers magenta ink; the Y-printhead 12e delivers yellow ink; and the OC-printhead 12f delivers an overcoat. The printheads 12a-12f may be similar in shape and construction, and they may be arranged in a single line.

[0013] The printing system 110 further includes a mechanism 114 for moving the carriage assembly 112 in a forward scan direction (X1) and a reverse (opposite) scan direction (X2), and a mechanism 116 for feeding a print medium (e.g., a sheet of paper) in a media axis

direction (Y1). The media axis direction (Y1) is generally perpendicular to the scan directions (X1 and X2).

[0014] The printing system 110 further includes a controller (e.g., a microprocessor and ROM) 118 for controlling the mechanisms 114 and 116 and the firing of the printheads 12a-12f. During multi-pass printing, for example, the carriage assembly 112 and, therefore, the printheads 12a-12f may be directed to scan or pass across a medium in the forward scan direction (X1) and then in the reverse scan direction (X2). Before certain passes of the carriage assembly 112 begin, the print medium is fed a specific distance. This serves to systematically advance unprinted areas of the print medium into printing alignment with the carriage assembly 112.

[0015] The controller 118 sends swath data to ink ejection elements in the printheads 12a-12f during printing. The swath data causes certain ink ejection elements of the ink printheads 12b-12e to deposit ink onto a print medium as the carriage is moved relative to the medium. The swath data may also cause certain ink ejection elements of the fixer and overcoat printheads 12a and 12f to deposit fixer and overcoat onto the deposited ink. The swath data may be generated entirely by the controller 118. For example, a host (e.g., a personal computer) sends RGB data for the image to be printed to the printing system 110, and the controller 118 converts the RGB data into swath data (in KCMY color space) for the ink printheads 12b-12e. The swath data for the fixer and overcoat printheads 12a and 12f may be generated by OR'ing all of the ink printhead swath data together, if fixer and overcoat are to be deposited wherever ink is deposited. Fixer and overcoat might be desirable for print media such as plain paper. However, fixer and overcoat might not be desirable for other types of print media. The type of media could be determined prior to generating the swath data (e.g., manually by a user who inputs the media type to the printing system 110, automatically by a sensor distinguishes the different types of media). If the fixer and overcoat are not desired, swath data is not generated for the fixer and overcoat printheads 12a and 12f.

[0016] In the alternative, the swath data for the ink printheads 12b-12e may be generated by the host, and the swath data for the fixer and overcoat printheads 12a and 12f may be generated by the controller 118. Or, the swath data for all of the printheads 12a-12f may be generated by the host.

[0017] Reference is made to Figure 2, which shows one of the printheads 12. The printhead 12 has a generally rectangular configuration and includes a number of separate ink ejection elements 14. The ink ejection elements 14 are arranged in two separate rows. A number of electrical contacts (not shown) are provided for electrically coupling the printhead 12a with the controller 118 to selectively activate the various ink ejection elements 14.

[0018] While the number of ink ejection elements 14 is purely a design choice, a typical inkjet printhead 12 may have 524 total ink ejection elements arranged in two staggered 300 dpi rows. One row may be offset from the other row by one sixth-hundredth of an inch to create a 600 dpi printhead resolution. However, not all of the ink ejection elements 14 might be active during printing. For example, only $N=500$ of the 524 ink ejection elements might be active during printing.

[0019] The active ink ejection elements 14 may be logically divided into four separate, contiguous groups, with the first group having N_1 ink ejection elements, the second group having N_2 ink ejection elements, the third group having N_3 ink ejection elements, and the fourth group having N_4 ink ejection elements. As an example, each group may have approximately one-quarter or $N/4$ ink ejection elements (that is, $N_1=N_2=N_3=N_4=N/4$), where N represents the number of active ink ejection elements in a given printhead. This example will be used below. It is understood, however, that the present invention is not limited to this example, and that the groups may have different numbers N_1 , N_2 , N_3 and N_4 of ink ejection elements 14. Moreover, it is understood that the ink ejection elements 14 may be logically divided into any number M of groups, where integer $M>1$.

[0020] During a printing operation in which fixer and overcoat are to be applied on top of the deposited inks, certain ink ejection element groups of each printhead 12a-12f are

active, while the remaining ink ejection element groups are inactive. Null swath data (e.g., 0's) may be sent to the inactive ink ejection elements. For example, only the first and second groups of the color ink printheads 12b-12e are active, and only the third and fourth groups of fixer and overcoat printheads 12a and 12f are active. Consequently, only the first and second groups of ink ejection elements of the ink printheads 12b-12e are used to deposit ink, and only the third and fourth groups of ink ejection elements of the fixer and overcoat printheads 12a and 12f are used to deposit fixer and overcoat on the ink. Moreover, null swath data is always sent to the third and fourth ink ejection element groups of the ink printheads 12b-12e and the first and second ink ejection element groups of the fixer and overcoat printheads 12a and 12f.

[0021] Reference is now made to Figure 3, which shows a first example of such a windowed print mode of operation. In the example, printing is performed in four passes, with each of four groups having the same number of ink ejection elements 14 (e.g., $N1=N2=N3=N4=125$). The first group of ink ejection elements includes ink ejection element numbers 1-125, the second group includes ink ejection element numbers 126-250, the third group includes ink ejection element numbers 251-375, and the fourth group includes ink ejection element numbers 376-500. In the paragraphs that follow, the number numbers will be indicated in parentheses.

[0022] As the first set of rows on the print medium is printed, the print head carriage assembly 112 makes a first pass in the forward scan direction (X1). The first group of ink ejection elements (ink ejection elements 1-250) of the ink printheads 12b-12e is active. Thus, only the first group of ink ejection elements (ink ejection elements 1-125) actually deposits ink onto the print medium during the first pass (step 310). No fixer or overcoat is deposited on the first set of rows by the fixer and overcoat printheads 12a and 12f during the first pass.

[0023] Prior to the second pass, the print medium is advanced a specified distance in the media axis direction (Y1) (step 312). The actual distance moved by print medium may be equal to approximately one-quarter of the number of active ink ejection elements or approximately 0.208 inches for a printhead resolution of 600 dpi.

[0024] During the second pass, the first and second groups of ink ejection elements (ink ejection elements 1-250) of each ink printhead 12b-12e are active (step 314). As the carriage assembly 112 is moved in the reverse scan direction (X2), color ink is ejected onto the first set of rows from the second group of ink ejection elements (ink ejection elements 1-250) of each ink printhead 12b-12e. In addition, color ink is ejected onto a second set of rows from the first group of ink ejection elements (ink ejection elements 1-125) of each ink printhead 12b-12e. At the conclusion of the second pass, the carriage assembly 112 will have made two separate scans in opposite directions across the print medium.

[0025] The print medium is again advanced the specified distance in the media axis direction (Y1) (step 316), and a third pass of the carriage assembly 112 is initiated in the forward scan direction (X1). During the third pass (step 318), the third group of ink ejection elements (251-375) of the fixer and overcoat printheads 12a and 12f is active. During the third pass, the third group of ink ejection elements (ink ejection elements 251-375) of the fixer and overcoat printheads 12a and 12f eject droplets of fixer and overcoat onto the first set of rows. In the meantime, the second group of ink ejection elements (126-250) of the ink printheads 12b-12e are active and deposit ink onto the second set of rows, and the first group of ink ejection elements (1-125) of the ink printheads 12b-12e are active and depositing ink onto a third set of rows.

[0026] Upon completion of the third pass number, the print medium is once again moved the specified distance in the media axis direction (Y1) (step 320). A fourth pass is then initiated (step 322). During the fourth pass, the carriage assembly 112 is once again moved in the reverse scan direction (X2). The third and fourth groups of ink ejection elements (ink ejection elements 251-500) of the fixer and overcoat printheads 12a and 12f are active and deposit fixer and overcoat on the second and first lines, respectively. In the meantime, the second group of ink ejection elements (126-250) of the ink printheads 12b-12e are active and deposit ink onto the third line, and the first group of ink ejection elements (1-125) of the ink printheads 12b-12e are active and deposit ink onto a fourth line.

[0027] As each subsequent line (5, ..., k, ... L) is printed, the fourth groups of ink ejection elements (375-500) of the fixer and overcoat printheads 12a and 12f deposit fixer and overcoat onto the kth line, the third groups of ink ejection elements (251-375) of the fixer and overcoat printheads 12a and 12f deposit fixer and overcoat onto the k+1th set of rows, the second groups of ink ejection elements (126-251) of the ink printheads 12b-12e deposit ink onto the k+2th set of rows, and the first groups of ink ejection elements (1-125) of the ink printheads 12b-12e deposit ink onto the k+3th set of rows. Null swath data is repeatedly sent to the first and second groups of ink ejection elements of the fixer and overcoat printheads 12a and 12f, and null swath data is repeatedly sent to the third and fourth groups of ink ejection elements of the ink printheads 12b-12e.

[0028] A particular benefit of the multi-printhead, multi-pass system is that the deposited ink can partially dry on the print medium before the fixer and overcoat are applied. As the number of passes increases, ink already ejected onto the media is able to at least partially dry before the fixer and overcoat are applied. Heat may be applied to accelerate the drying.

[0029] The printing system 110 is not limited to the four-pass mode of operation just described. By altering the subsets of ink ejection elements mapped for each printhead, it becomes possible to alter the number of passes needed to deliver ink, fixer and overcoat to the sheet. The number of passes may be changed by changing the number of ink ejection element groups, the number of ink ejection elements in each group, and the distance for each advance of the print medium.

[0030] Reference is made to Figure 4, which shows a second example of a windowed print mode of operation. In this second example, printing is performed in two passes. During the first pass, only ink is applied by the first and second groups of ink ejection elements of each ink printhead 12b-12e (step 410). No overcoat or fixer are applied. The print medium is advanced by a half-printhead height (step 412). Ink is deposited by the first and second groups of ink ejection elements, and fixer and overcoat are deposited by the third and fourth groups

of ink ejection elements of printheads 12a and 12f during the second pass (step 414). For each additional line, steps 410 and 412 are repeated.

[0031] Although an example was given above in which each printhead 12a-12f had 524 total ink ejection elements and N=500 active ink ejection elements, the printheads 12a-12f are not so limited. Each printhead 12a-12f may have a considerably fewer number of active ink ejection elements during a single scan. The number of active ink ejection elements may be altered by altering the number of passes necessary for a single print cycle.

[0032] The printheads may be arranged in a single line to reduce the overall size or footprint of the print head carriage assembly. This single-line configuration may be used in a non-windowed mode of operation, in which full height of each printhead 12a-12f is used. However, in order to deposit fixer and overcoat on the ink in a single pass, the carriage assembly shown in Figure 1 may be modified by adding a second fixer printhead and a second overcoat printhead. The second fixer printhead may be arranged next to the overcoat printhead 12f, thereby allowing fixer and overcoat to be deposited on the ink while the carriage assembly is moving in the forward scan direction (X1). The second overcoat printhead may be arranged next to the fixer printhead 12a, thereby allowing fixer and overcoat to be deposited on the ink while the carriage assembly is moving in the reverse scan direction (X2).

[0033] The present invention is not limited to a single line configuration. Instead, the printheads may be staggered in a number of separate lines.

[0034] If a staggered printhead arrangement is used, and the fixer and overcoat printheads print in a different set of rows than the ink printheads, then a non-windowed mode of operation may be used. Thus the full height of each printhead may be used for printing. Examples of staggered printhead arrangements are shown in Figures 5a-5d.

[0035] Reference is now made to Figure 5a, which shows a carriage assembly 510 having a staggered arrangement of printheads 12a-12f. The ink printheads 12b-12e are located in a first row, and the fixer and overcoat printheads 12a and 12f are located in a spaced-apart

second row. During a first pass, swath data is sent to all groups of ink ejection elements of the ink printheads 12b-12e. Each subsequent set of rows is printed by advancing the print medium by a full printhead height, and sending swath data is sent to all groups of ink ejection elements of each printhead 12a-12f. The fixer and overcoat printheads apply fixer and overcoat to the ink applied during the previous pass, and the ink printheads create a new set of rows of ink.

[0036] The carriage assembly 530 of Figure 5b has a first row of ink printheads 12b-12e and a second row of fixer and overcoat printheads 12a and 12f. The first and second rows overlap by a couple of ink ejection elements.

[0037] The carriage assembly 550 of Figure 5c includes fixer and overcoat printheads 552a and 552f that are half-height. The ink printheads 552b-552e are full-height. The half-height printheads are not operated in a windowed mode of operation. All ink ejection elements of the half-height printheads 552a and 552f are active, except during the printing of the first several passes and the last several passes. The print medium is advanced by half-height of the ink printheads 552b-552e.

[0038] Figure 5e illustrates three-pass printing of a single line by the carriage assembly 550. The ink ejection elements of the ink printheads 552b-552e are logically divided into two groups of $N/2$ ink ejection elements. The first group of ink ejection elements of the ink printheads 552b-552e deposit ink on a print medium during the first pass (step 570). The print medium is advanced (step 572), and the second group of ink ejection elements of the ink printheads 552b-552e deposit ink on a print medium during the second pass (step 574). The print medium is not advanced, and during the third pass the fixer and overcoat printheads 552a and 552f deposit fixer and overcoat (step 576).

[0039] The order in which fixer and overcoat are deposited onto the deposited drops of the colored ink will depend upon the print media and the type of fixer and overcoat that are used. In some instances it might be more desirable to deposit the fixer prior to depositing the

overcoat, in other instances it might be more desirable to apply the overcoat prior to depositing the fixer, and in still other instances the order might not matter.

[0040] Referring to Figure 5d, a carriage assembly 570 includes an additional fixer printhead 12g for allowing fixer to be deposited prior to overcoat, regardless of the direction (X1 or X2) in which the carriage assembly 570 is traveling. This enables the carriage assembly 570 of Figure 5d to perform bi-directional printing.

[0041] The printhead arrangements have been described above in connection with carriage assemblies. These printhead arrangements can also be applied to printer cartridges.

[0042] Reference is made to Figure 6, which shows a system 610 including a computer 612 connected to a printer 614. The computer 612 includes a processor 616 and memory 618 for storing a program 620 (e.g., a printer driver). The program 620 converts a file (e.g., a text document, an RGB image file) into swath data, and sends the swath data to the printer 614.

[0043] The printing systems described above can provide overcoat only where needed; therefore, the operating and overcoat/fixer volumetric efficiency is improved. Because the same data stream is utilized for controlling ejection of both the ink and the fixer and overcoat, the chance of the system malfunctioning is reduced. Because of the arrangement wherein each pass utilizes only certain ink ejection elements in each printhead, the ink can partially dry before application of the fixer and overcoat. An in-line printhead configuration can reduce the footprint of the carriage assembly.

[0044] The printing systems may be operated in a mode in which overcoat and fixer are not deposited. Null data is sent to the fixer and overcoat printheads, and full height of the ink printheads is used. Such a mode allows the printing systems to operate at higher throughput.

[0045] The printhead carriage assembly is not limited to the number and type of printheads described above. The number of printheads in the print head carriage assembly 112 may be changed to meet space and use requirements. For example, the black printhead may

be omitted, and other color ink printheads may be used to produce the omitted color (because black is a composite color, the dark grays and low optical density of black may be generated by appropriately combining the cyan, yellow and magenta ink printheads). Alternatively, a six-color ink system may be used instead of the previously-discussed four-color ink system. Instead of single C and M inks, a six-ink system may contain both light cyan (c) and dark cyan (C) inks, and light magenta (m) and dark magenta (M) inks, in addition to yellow and black.

[0046] The present invention is not limited to the specific embodiments described and illustrated above. Instead, the present invention is construed according to the claims that follow.